

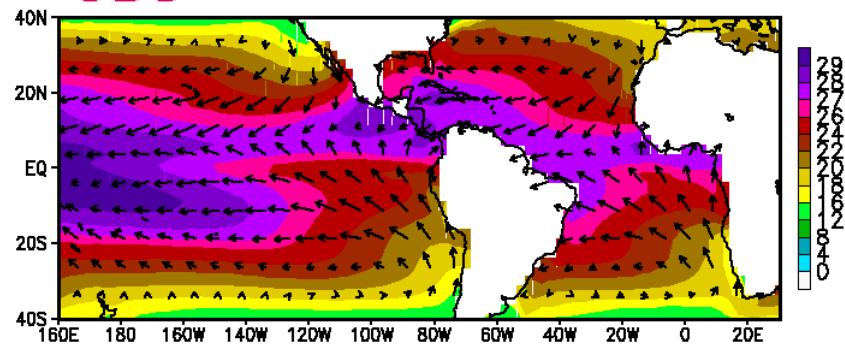
Synthesis NOAA Webinar

**"Evaluation and Improvement of Climate GCM Air-Sea
Interaction Physics:
An EPIC/VOCALS Synthesis Project"**

Chris Fairall
Yuqing Wang
Simon de Szoeke
X.P. Xie

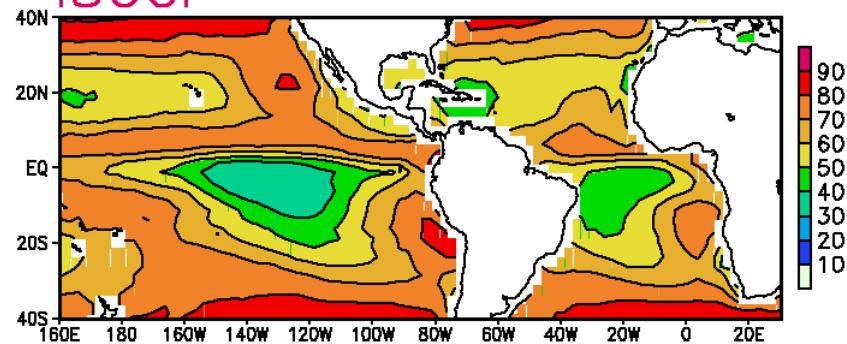
Annual Mean SST / Surf. Wind

OBS

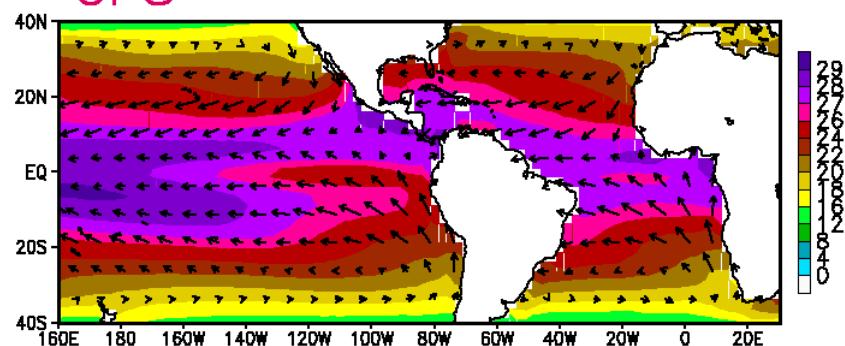


Annual Mean Total Cloud (%)

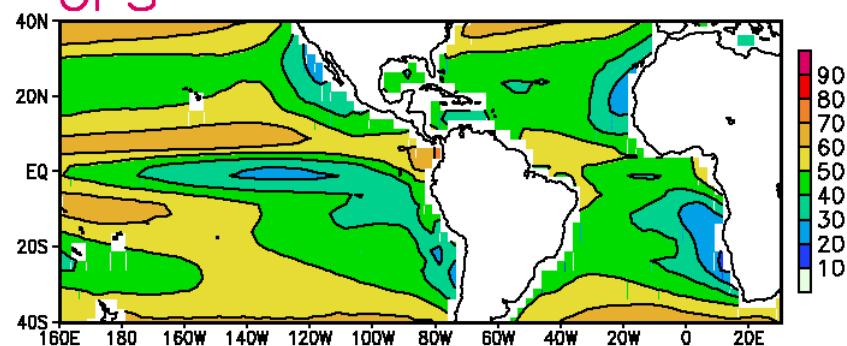
ISCCP



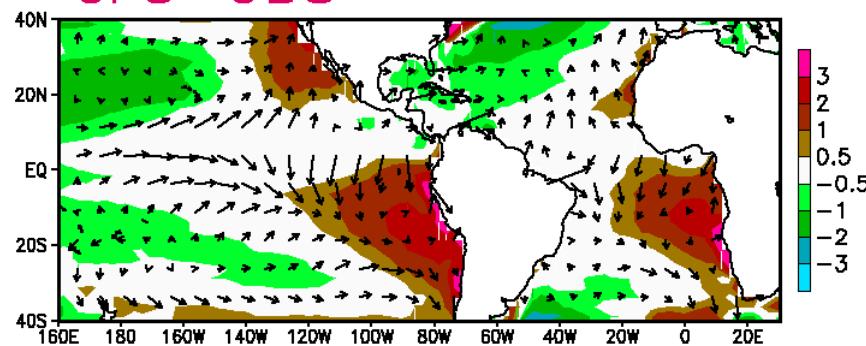
CFS



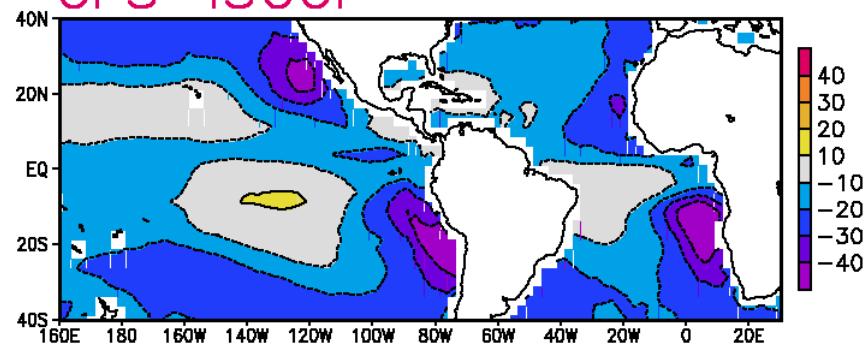
CFS



CFS-OBS

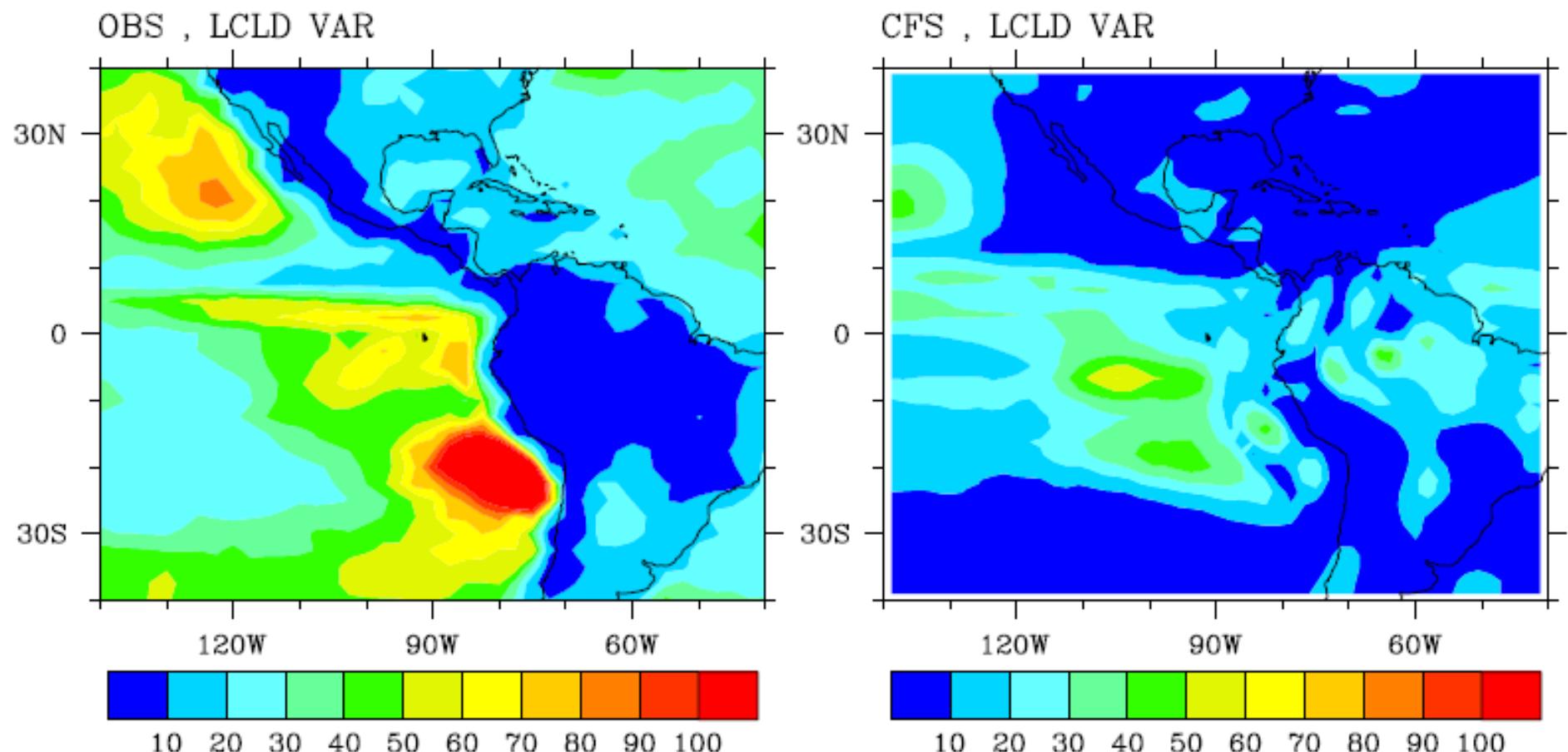
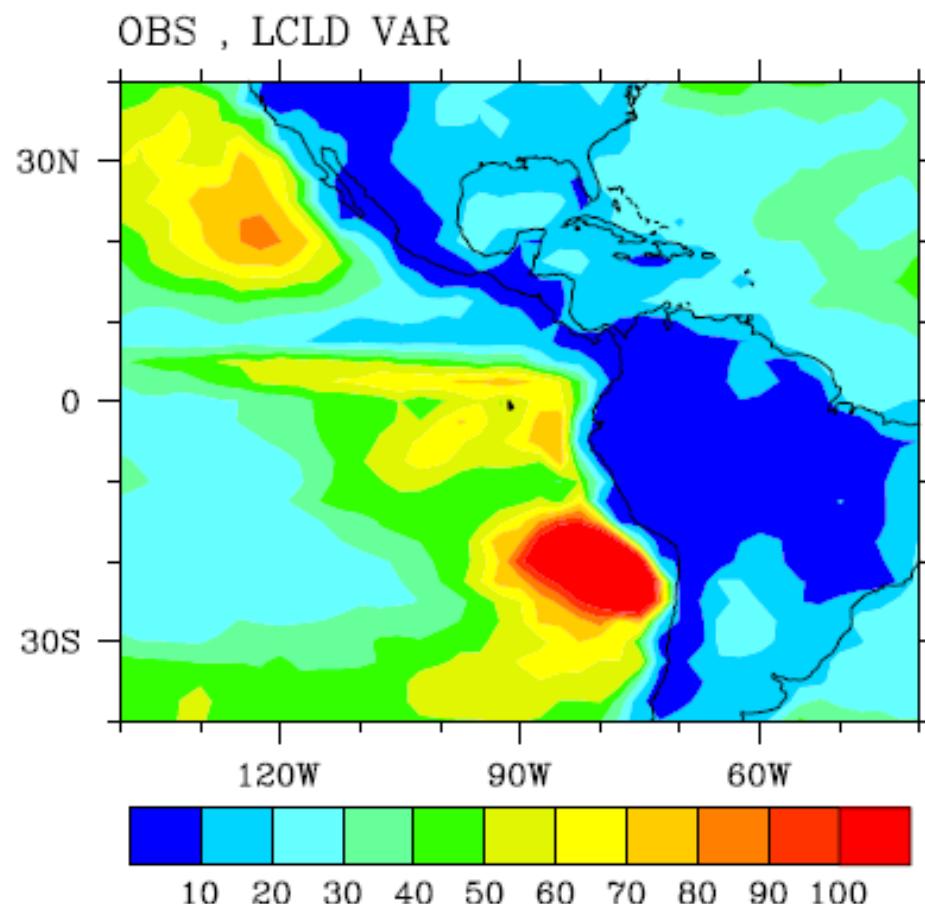


CFS-ISCCP



Provided by P.P. Xie

Variability



Background

- Approach: focus on clouds and surface fluxes
- Observations: **Statistical** in nature
 - EPIC monitoring: 8 cruises, **equatorial 95 and 110 W**
 - STRATUS monitoring: 8 cruises, **20 S 70 to 85 W**
 - Intensive field programs: EPIC2001, VOCALS 2008
 - Buoys (TAO equatorial; WHOI surface reference stratus)
 - Global ocean surface flux products
- High resolution regional model:
 - U Hawaii IRAM (atmosphere)
 - U Hawaii IROAM (couple ocean-atmosphere)
- Global climate models: IPCC AR4 archive

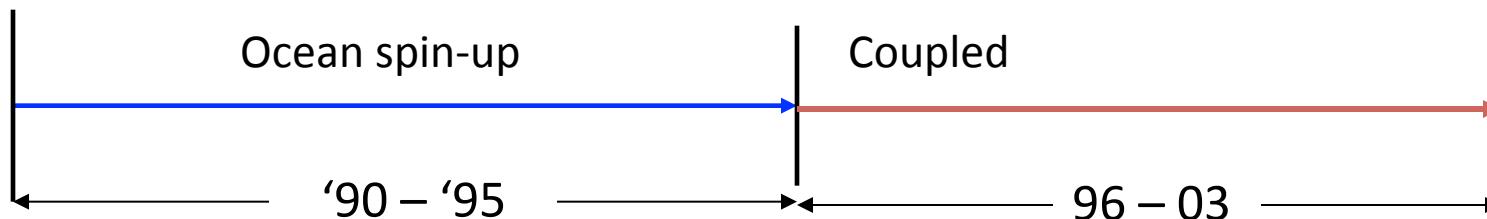
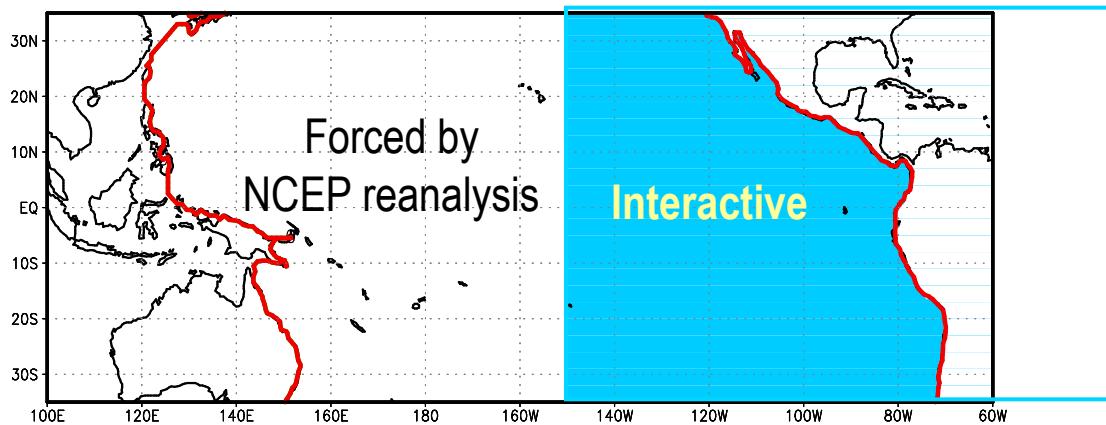
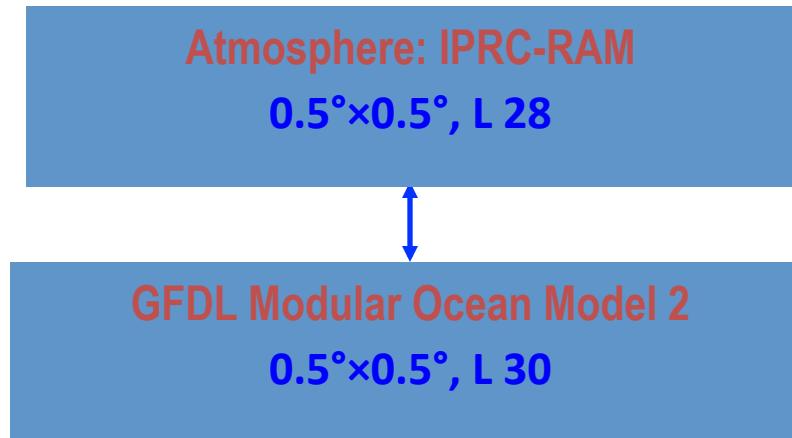
Data and Publications at:

<http://www.esrl.noaa.gov/psd/psd3/synthesis/>

Surface Flux and Cloud/Boundary-Layer Measurements from Ships and Buoys



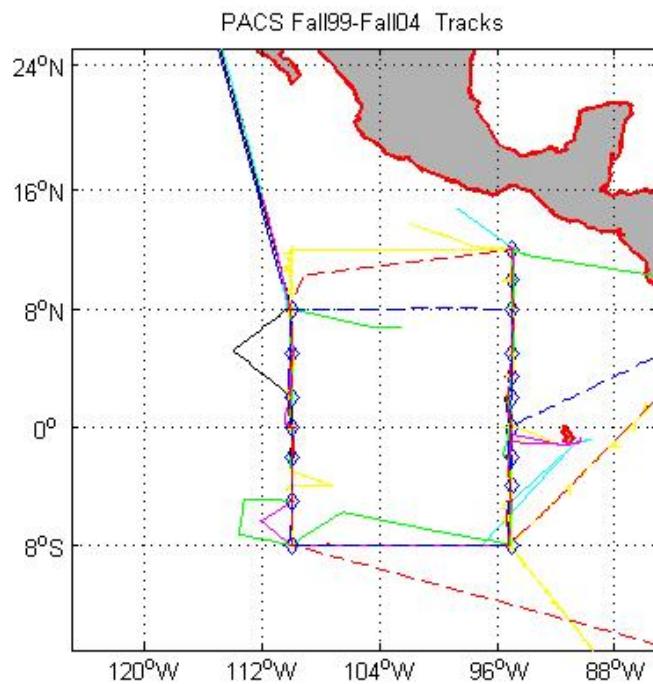
IOPC Regional Ocean-Atmosphere Model (iROAM) on ES



Models Vs Data ‘Climatology’: Equatorial Cruises

ESRL-PSD Tao Buoy

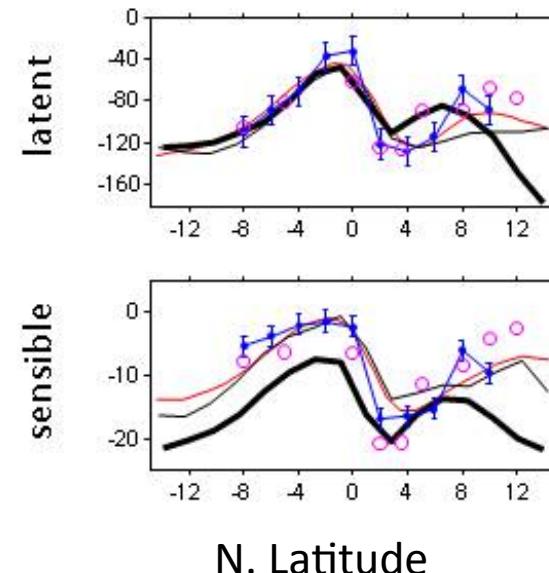
Maintenance Cruises, 6 October
and 3 April deployments: flux,
boundary-layer, cloud systems



$$NetHeatFlux = Solar_{net} + IR_{net} + Latent + Sensible$$

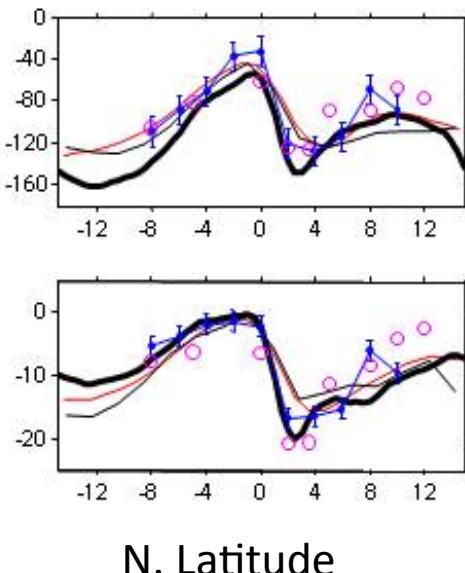
GFDL Coupled Model - IPCC

GFDL CM2.1



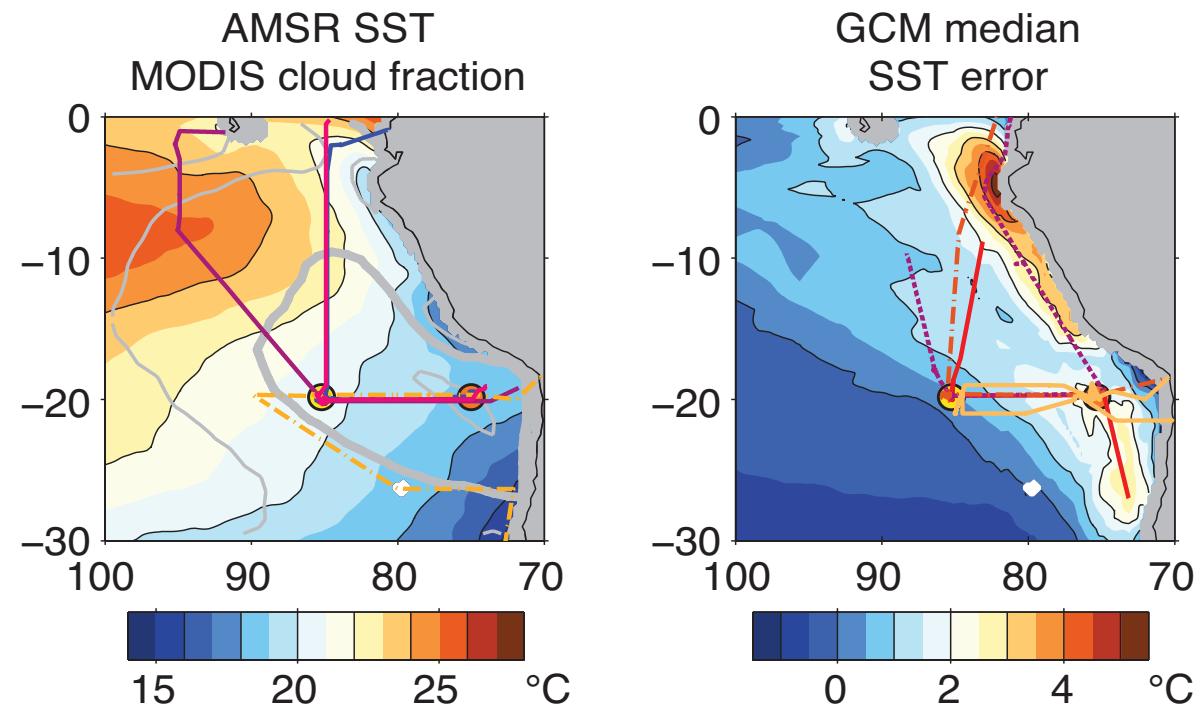
U. Hawaii Regional

IROAM



- Model
- TAO buoy
- WHOI(1984-2002)analysis [Yu and Weller 2007]
- CORE(1984-2004) [Large and Yeager 2004]
- + NOAA ship observations (1999-2002)[Fairall et al. 2008]

Eastern Pacific surface fluxes observed and simulated by coupled GCMs

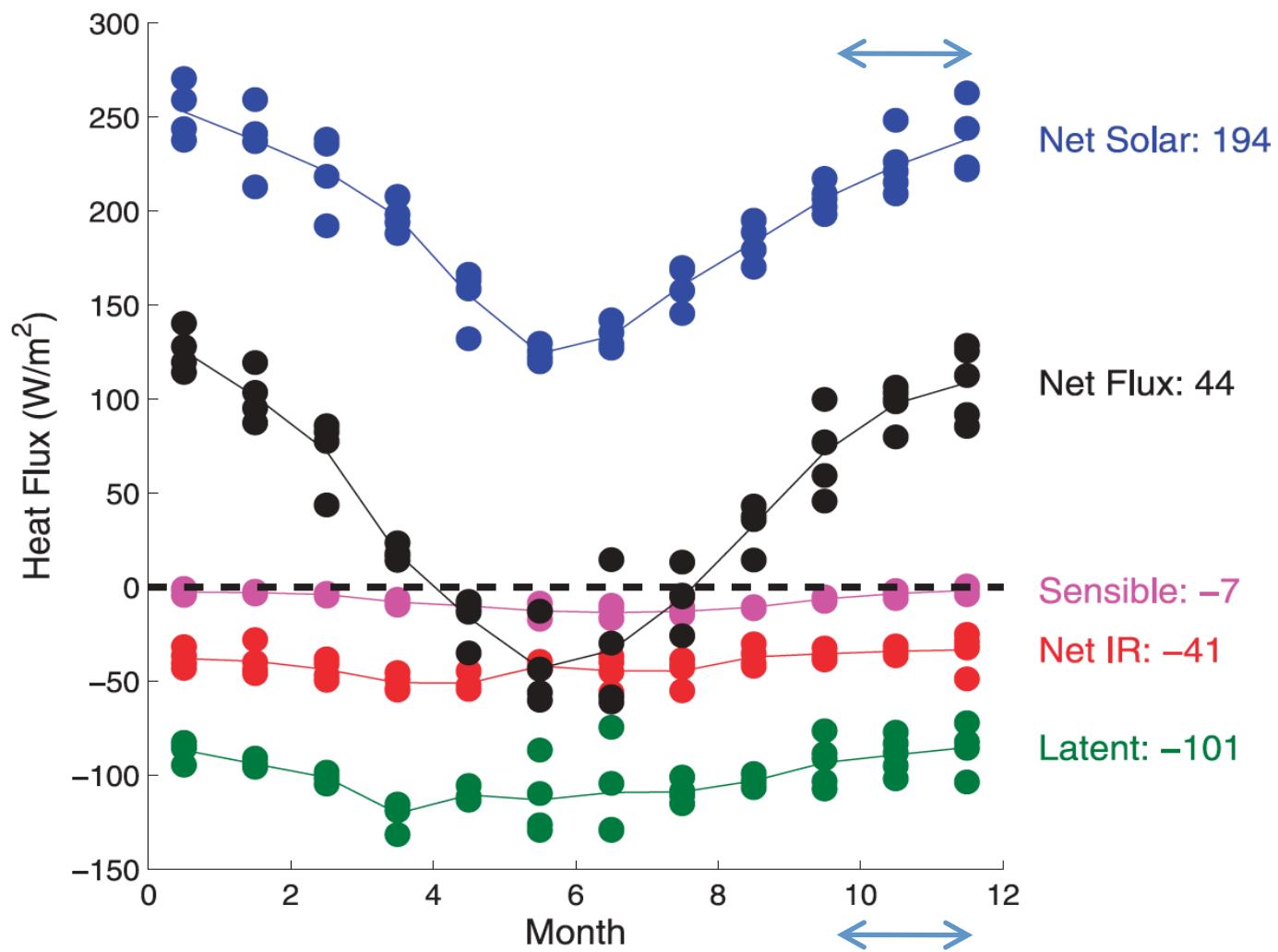


de Szoëke et al. 2010: Surface Flux Observations on the Southeastern Tropical Pacific Ocean and Attribution of SST Errors in Coupled Ocean–Atmosphere Models, *J. Climate*.

Surface ocean heat budget at 20 S 85 W

WHOI Buoy Annual Cycle

October

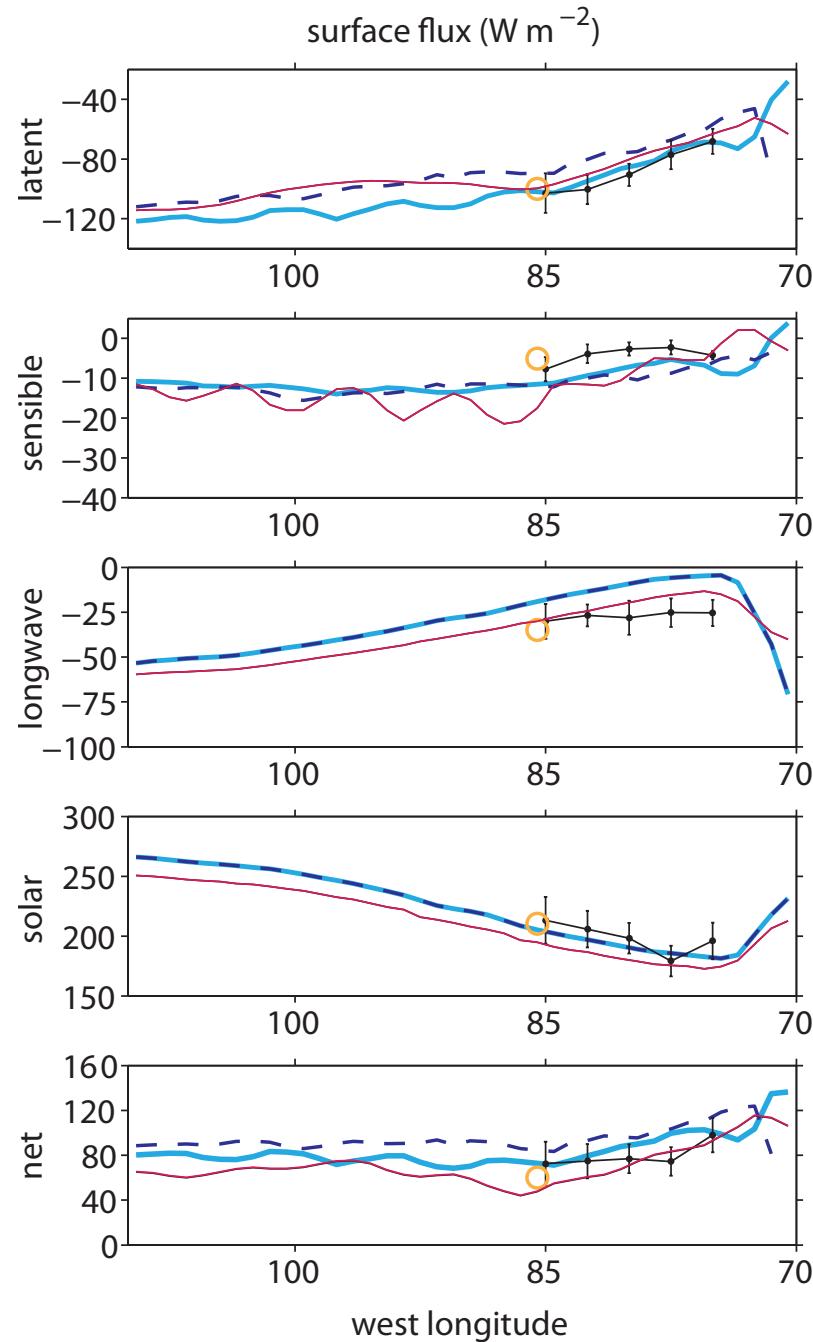


Colbo and Weller 2007

Ship-observed heat fluxes

20°S, October

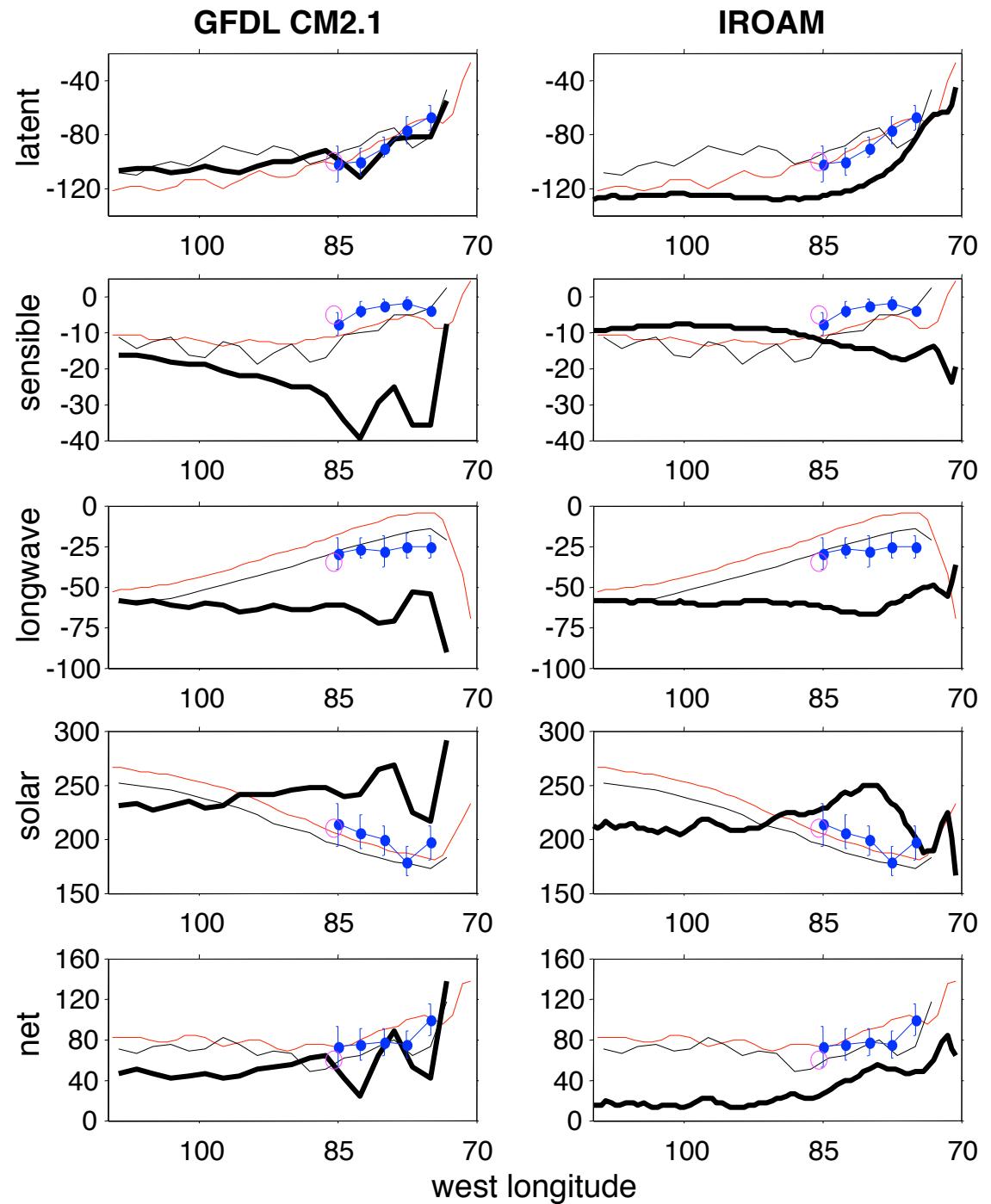
- WHOI OAFlux
- UW Hybrid
- NCAR CORE
- NOAA PSD ship
- WHOI buoy



Model heat fluxes

20°S, October

- Model
- WHOI ORS buoy
- OAFlux (1984-2002)
- CORE (1984-2004)
- NOAA ship observations



Surface Heat Budget

0 =

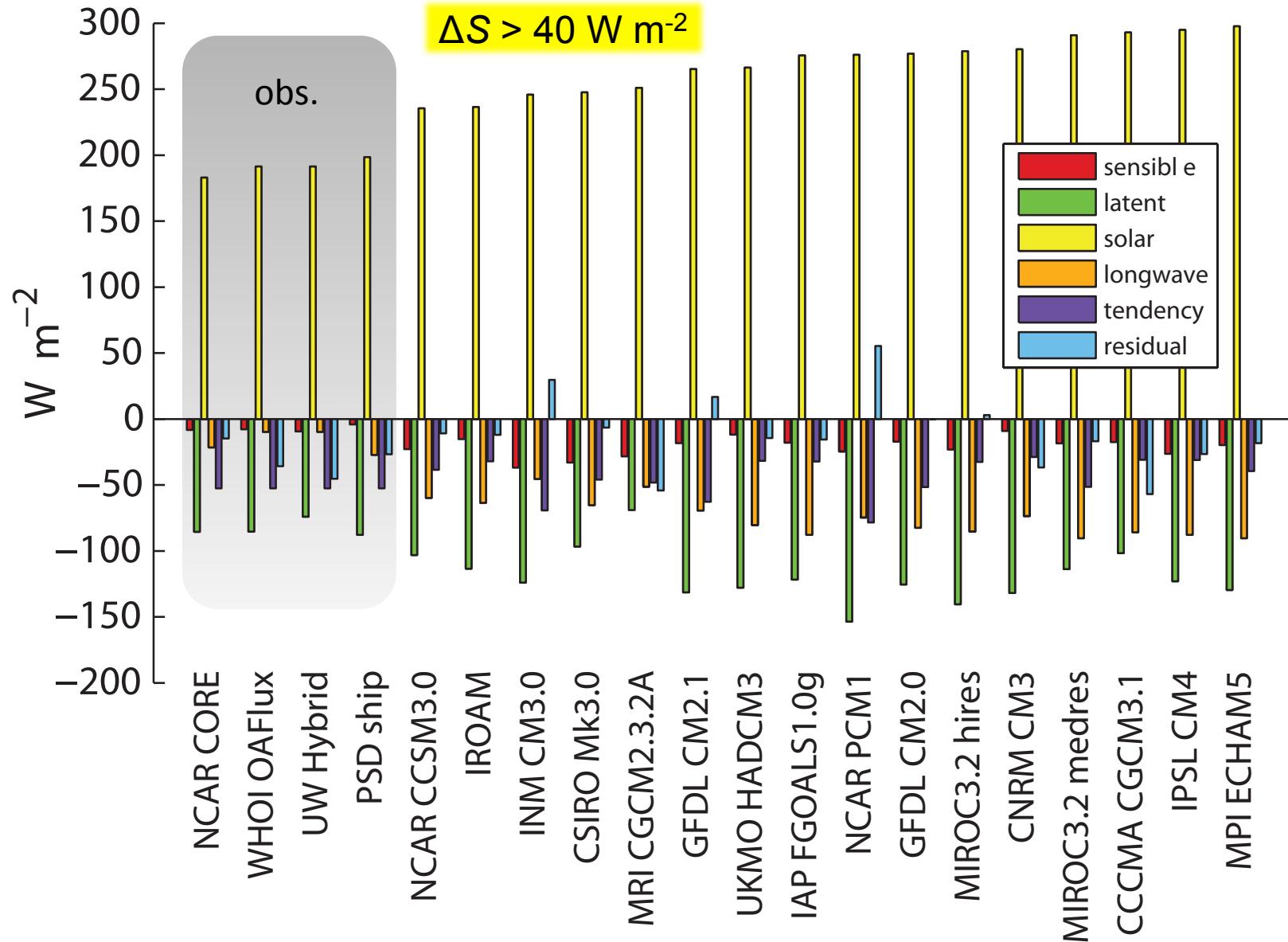
$-\partial/\partial t \text{ SST}^*h$

turbulent evaporation and sensible flux

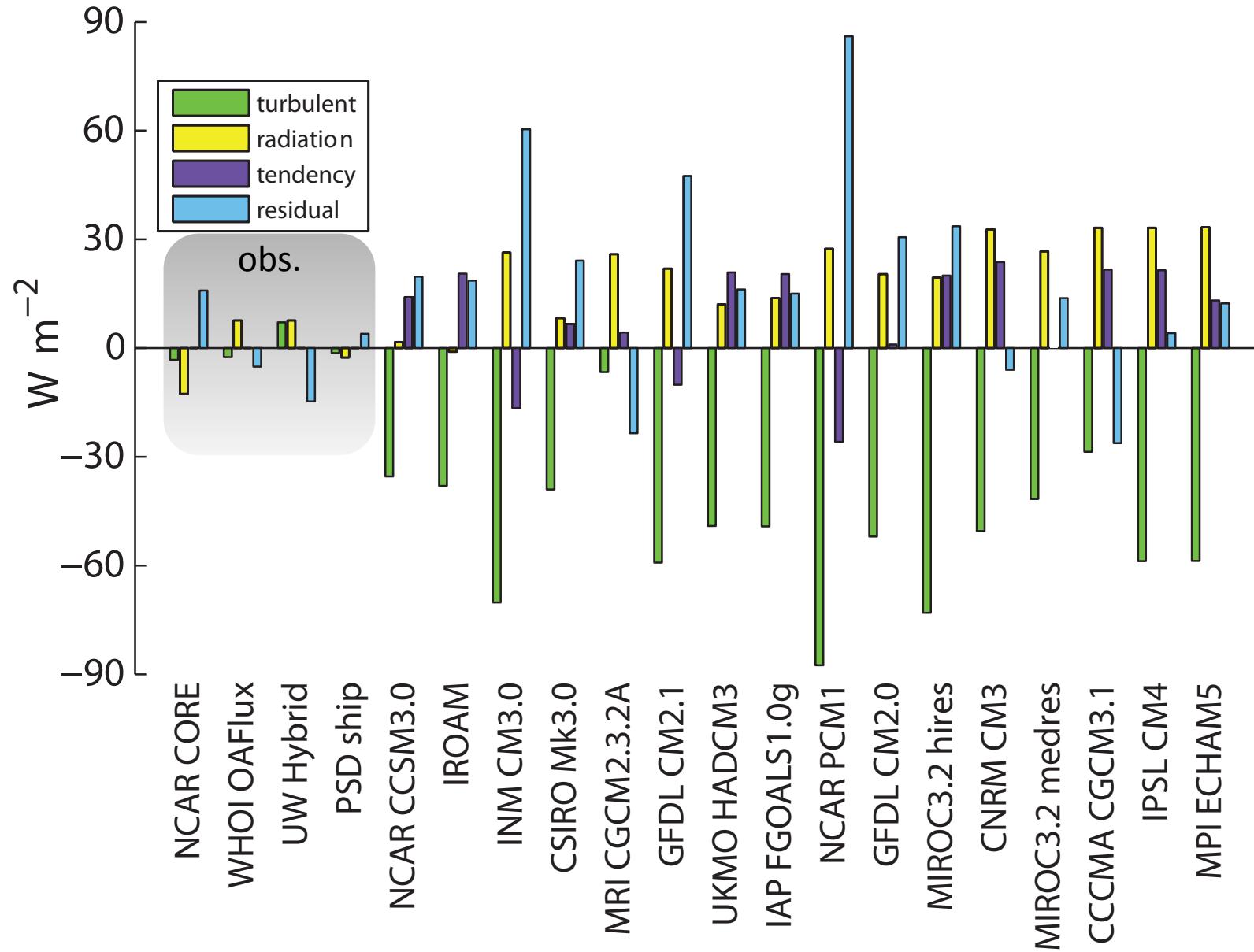
net radiation

ocean residual

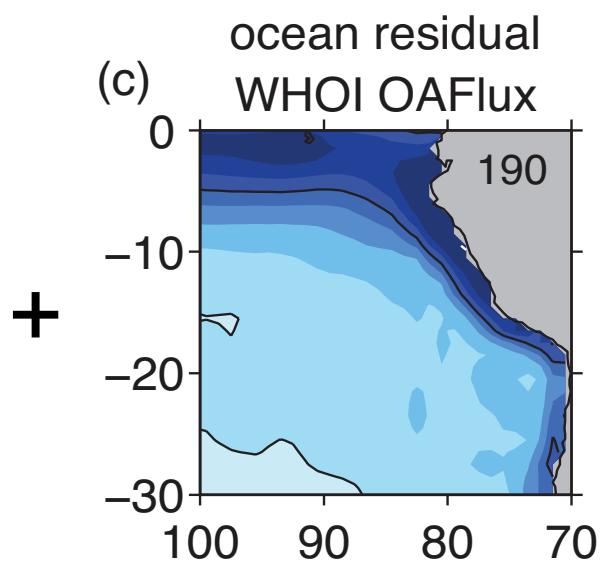
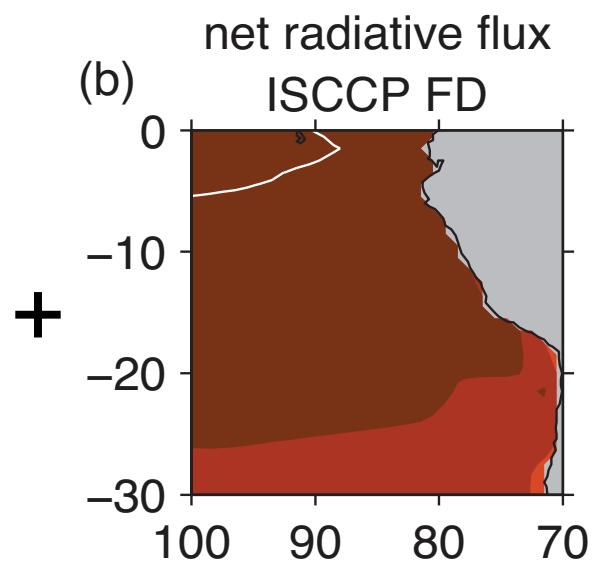
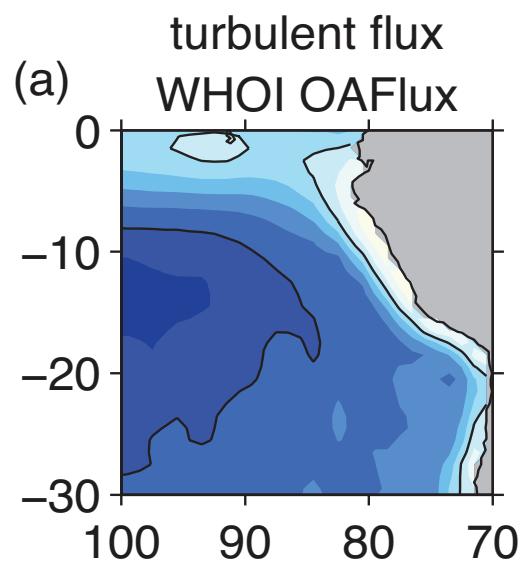
October Surface Heat Budget



October Surface Heat Budget *Errors*

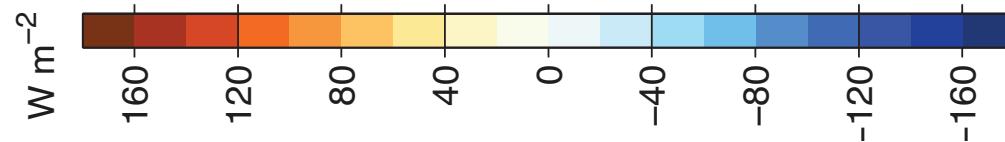


annual average heat budget



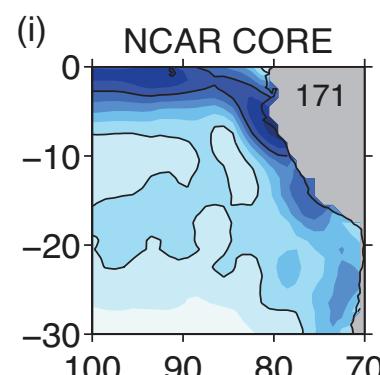
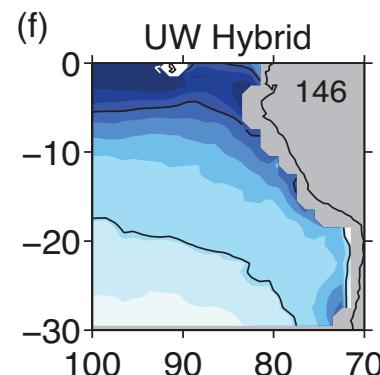
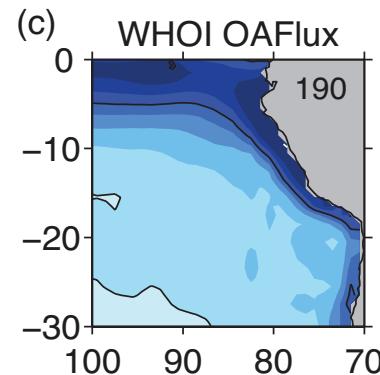
+

$$= 0$$

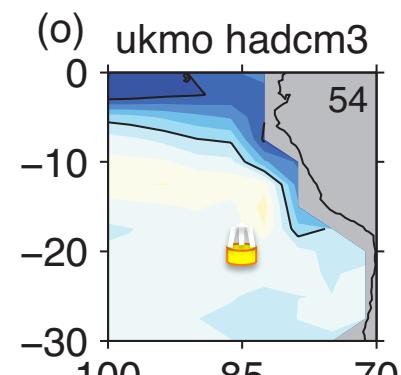
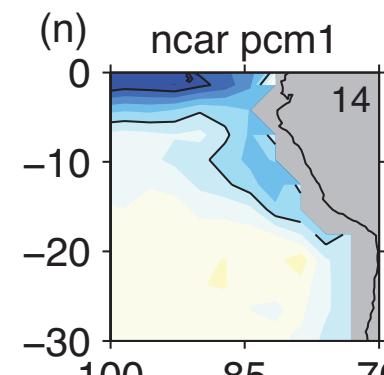
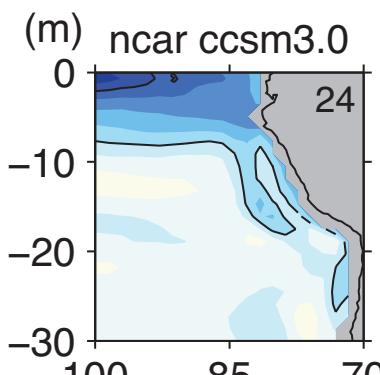
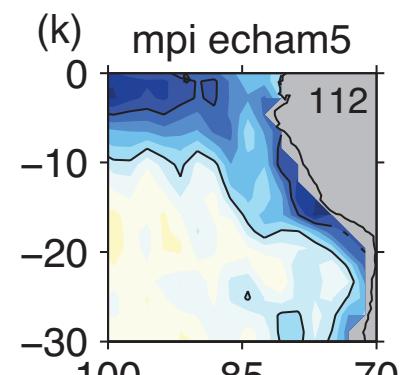
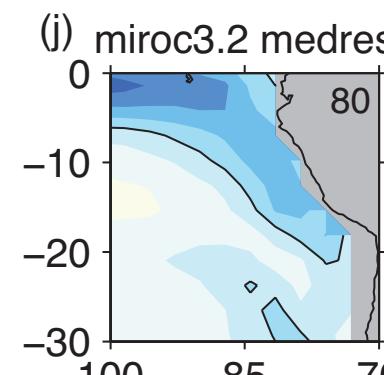
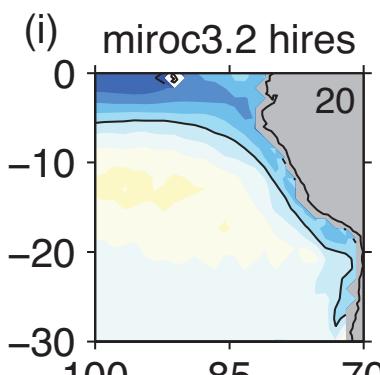
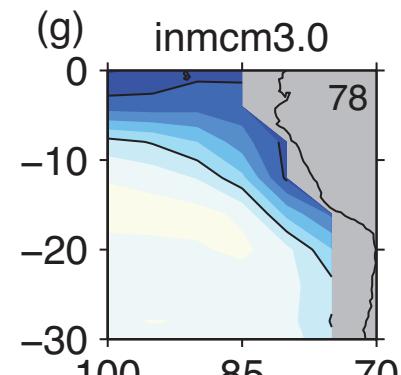
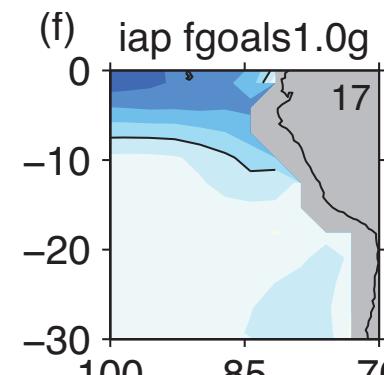
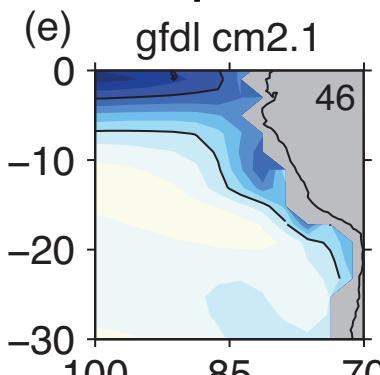


Ocean residual flux

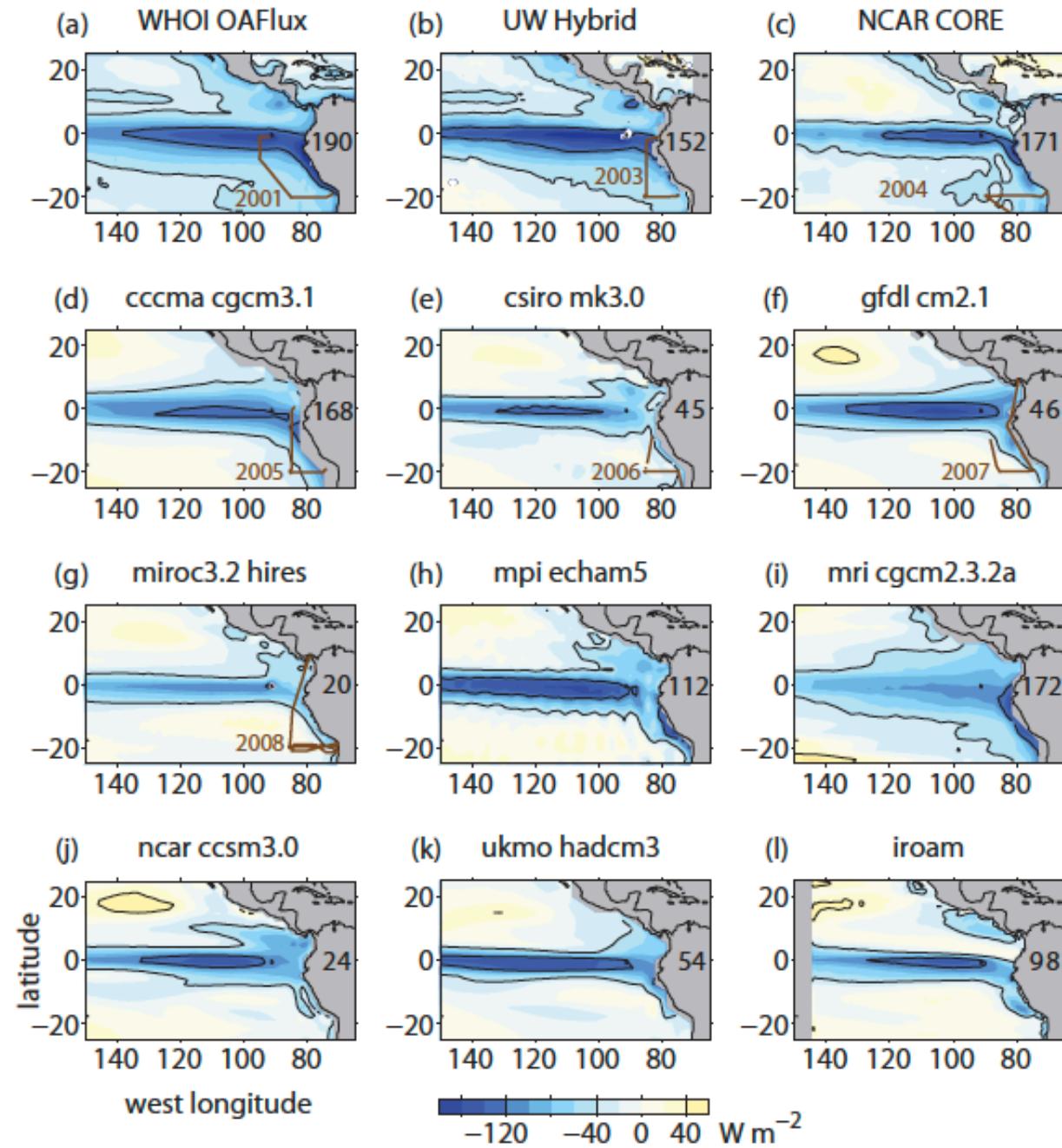
“observed”



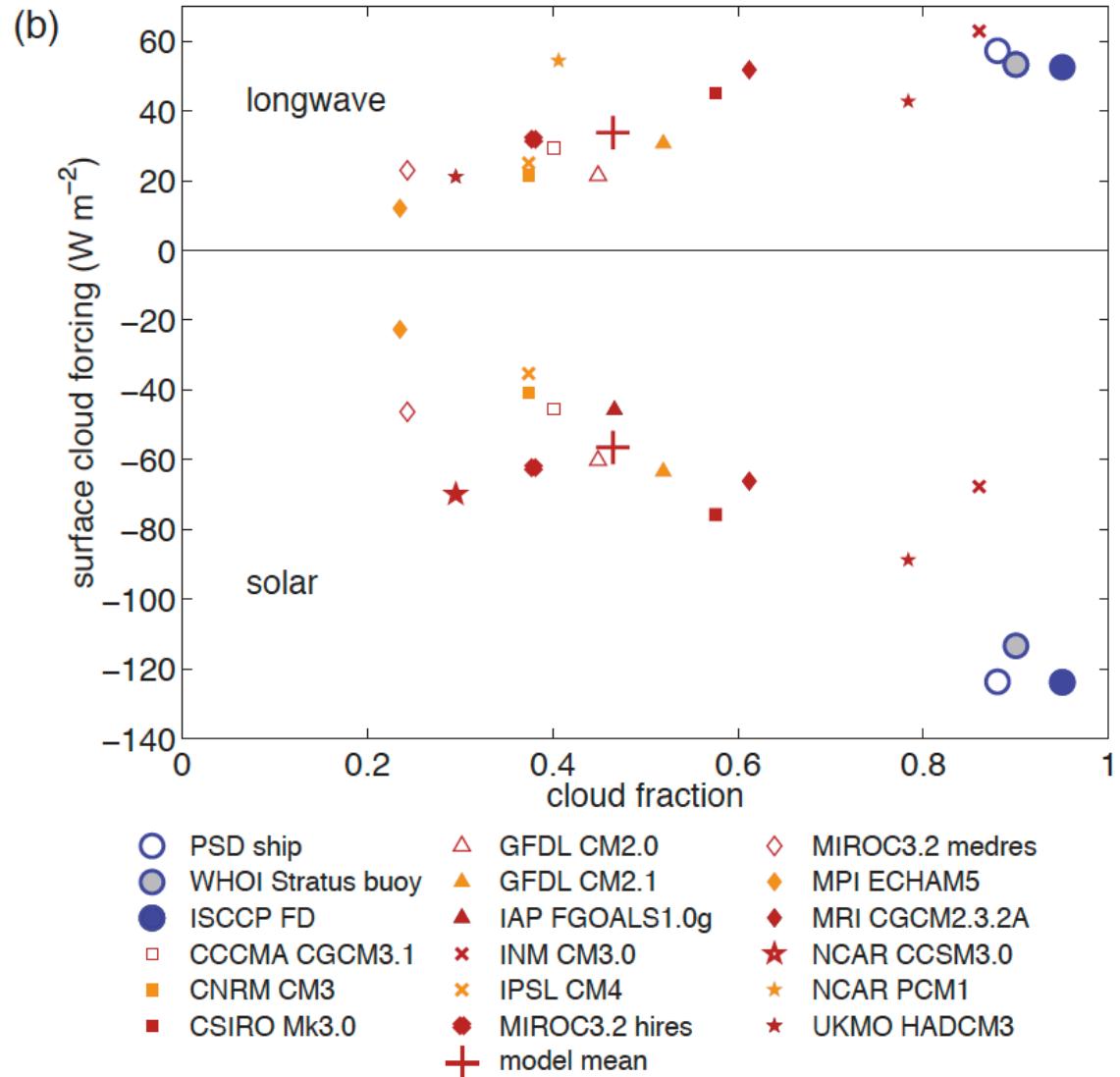
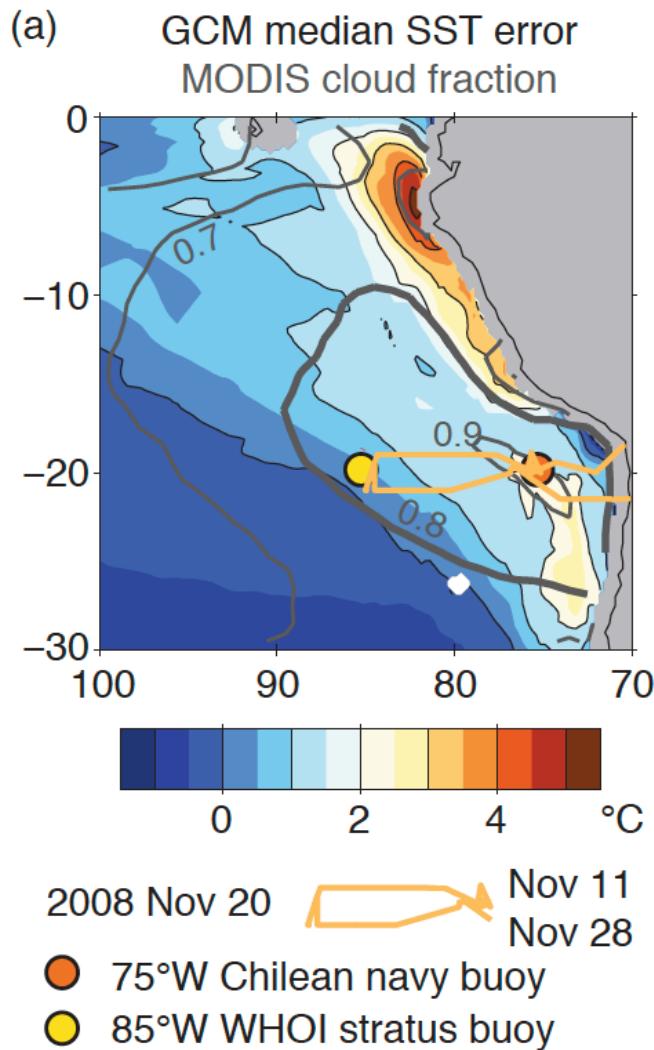
coupled GCM simulations



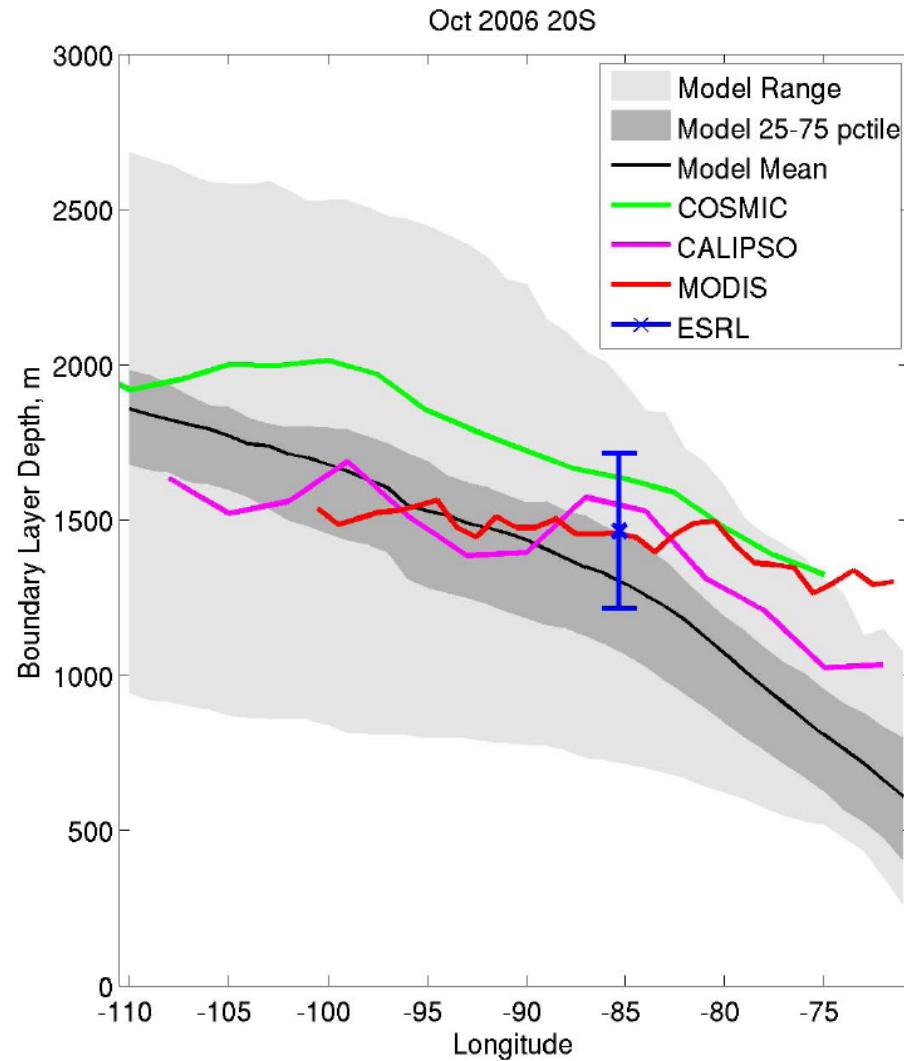
ocean contribution to surface heat budget



Cloud Forcing of Surface Radiative Fluxes: CF=<Observed Flux>-Clear Sky Flux



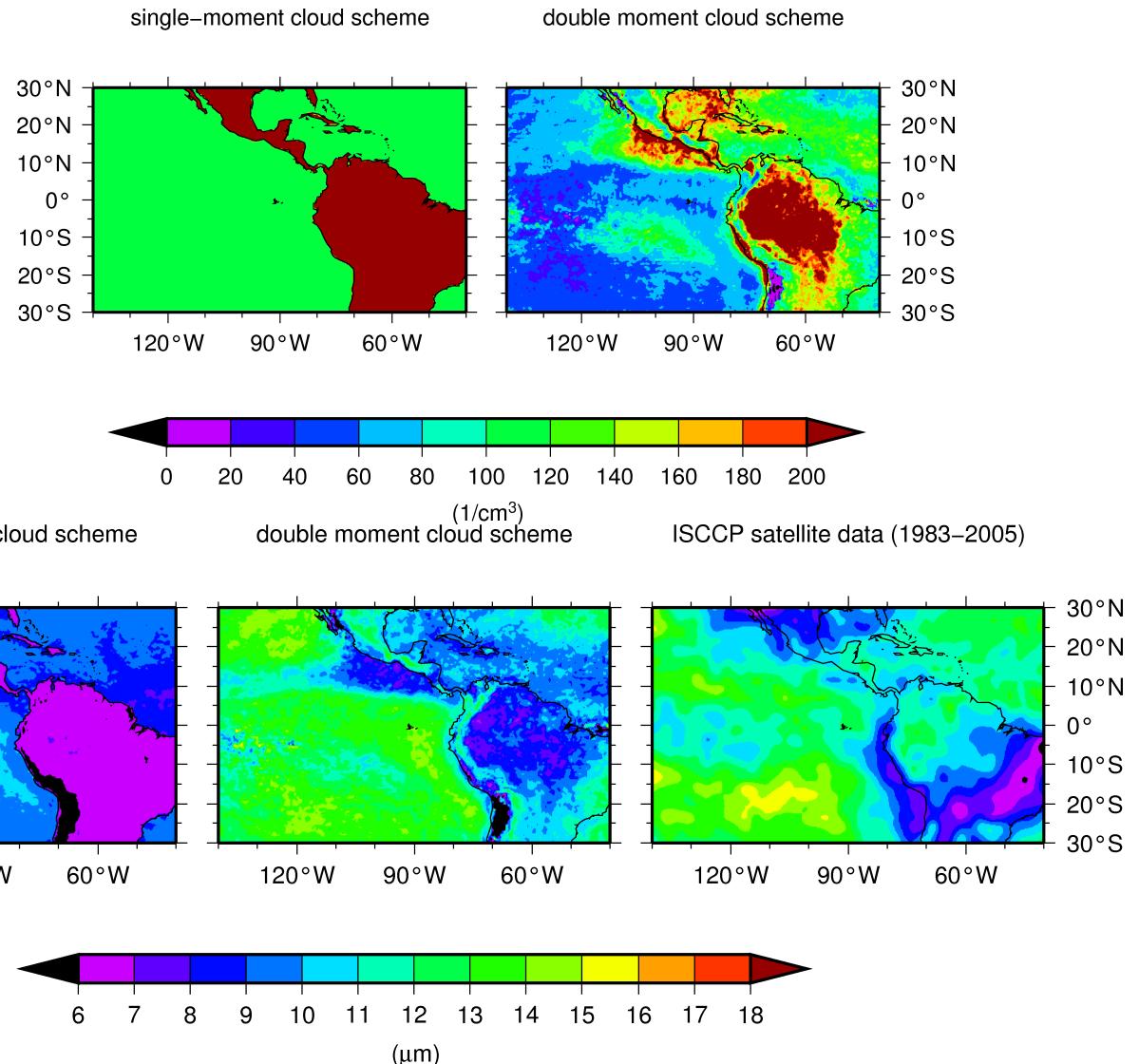
**Simple Cloud
Property:**
**Cloud top height
and/or Boundary
Layer height from in
situ, satellite, and
model**



- October 2006 model boundary layer depth (m) compared with observations of boundary layer depth and cloud-top height. Model mean (solid black line), 25–75 percentile range (dark gray), and model range (light gray) are plotted. COSMIC October 2006 boundary layer depth sampled over 15–25_S is plotted in green. CALIPSO cloud-top height is plotted in magenta. MODIS cloud top heights are plotted in red from Zuidema et al. (2009). The mean depth (blue x) is an October climatology estimated from NOAA/ESRL soundings taken near the stratus buoy, with standard deviation plotted.

Cloud Microphysics Complexity in IRAM

- Cloud droplet number concentration:
- Single moment = cloud water/ice
- Double moment = cloud water/ice linked to **aerosols**



Cloud effective radius: A balance of droplet number and total water

Conclusions

- Good accuracy for flux products
- IPCC models: radiation errors roughly cancelled by sensible+latent heat errors
- Some IPCC models have significant ocean heat flux errors
- Radiation errors principally caused by underestimate of cloud amount
- Cloud-aerosol coupling and improved shallow convection schemes required